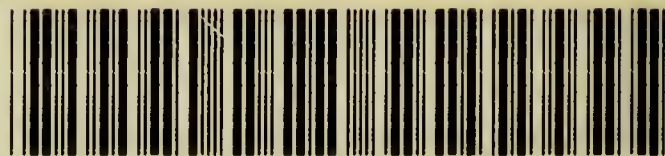


THE LIVER-FLUKE

AND

THE ROT IN SHEEP

EDWARD HALSE



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DEPARTMENT OF ANIMAL HEALTH
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SECTION:

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THE LIVER-FLUKE
AND
THE ROT IN SHEEP.

A Prize Essay.

BY
EDWARD HALSE, A.R.S.M.

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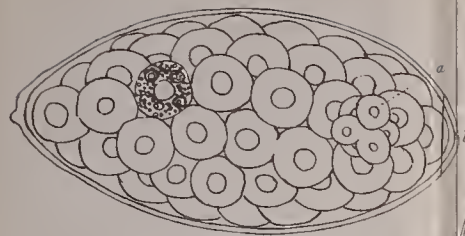
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Fig 1



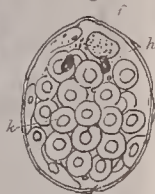
After Thomas
Mag 680 dia

Fig 2



Mag 370 dia

Fig 3



f, boring tool
h, eye spots
k, germinal cells
Mag 500 dia
After Thomas

Fig 4



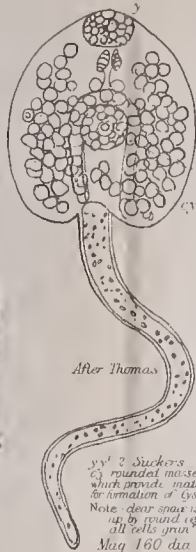
After Thomas
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Fig 5



After Thomas
Mag 330 dia

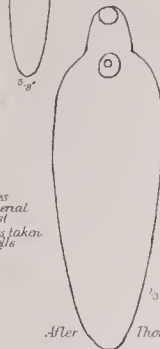
Fig 6



After Thomas

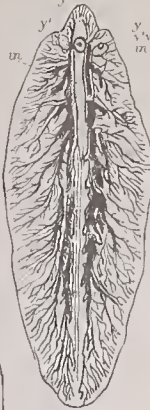
yy 2 suckers
of rounded masses
which provide material
for formation of cyst
Note: clear space is taken
up by round cells
all cells gran
Mag 160 dia

Fig 7



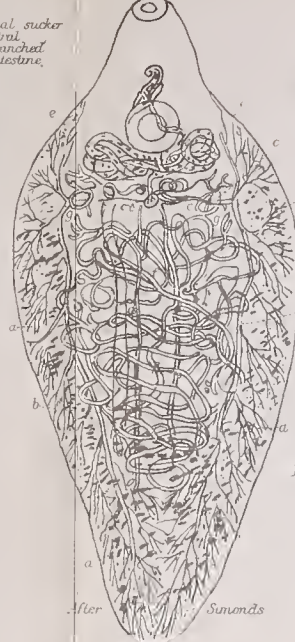
After Thomas
Mag 14 times

Fig 8



Mag 2 dia
After Thomas

Fig 9



After Simonds

Fig 10



L. peregr

Fig 11



After Blanchard

Fig 12



After Blanchard

Fig 13

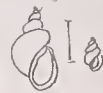


Fig 16



Mag 280 dia
After Cobbold

Fig 17



Mag 260 dia
After Cobbold

Fig 14

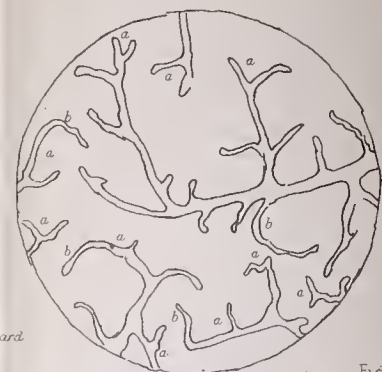


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P R E F A C E .

THE following essay was written while the author was studying for a short period at the Agricultural College and Training Farm, Alvecote Priory, Tamworth, and it gained the first prize offered by Miss Eleanor A. Ormerod, consulting entomologist to the Royal Agricultural Society, on the subject of liver-fluke, and its bearing on the rot in sheep. The competition was confined to past and present students of the Tamworth and Aspatia Colleges.

In the following pages slight claim only is laid to originality, the subject matter being in a great measure taken from the

books and papers quoted in the text. The author is induced to publish the essay for the reason that no publication on the subject, embodying the recent researches of Professor Thomas, together with those of former observers, exists, and with the hope that it may find its way into the hands of agricultural students and sheep-farmers, thus aiding them in understanding both the cause and the effect of the rot, and showing them how the disease, which, under favouring circumstances, often becomes a direful plague, may be kept down to normal limits.

Miss Ormerod, in a letter to the author written last January, lays great stress on the need of the prevention of the spread of fluke, especially "where there are many small weed-grown watering-places, little

dirty ponds, and the like suitable for the propagation of the water snail *Limnæus*, the ‘host’;” and she adds, “on my father’s Gloucestershire property there were numbers of such pools (as well as rabbits in the cliffs), and under the influence of the pests spread in the pastures from both causes the sheep suffered fearfully.”

EDWARD HALSE.

March, 1887.

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Notting Hill, London, W.

THE LIVER-FLUKE

AND

THE ROT IN SHEEP.

PART I.

THE POSITION OF THE LIVER-FLUKE IN THE ANIMAL KINGDOM.

THE liver-fluke* is so named because it passes the adult stage in the liver of the sheep and other quadrupeds. It has also been called the fluke-, flounder-, gourd-, or plaice-worm† from its flatness (it has no

* Two other flukes, *Distoma lanceolatum* and *Amphistoma conicum*, occur in the sheep, but their effects are as yet unknown. Sometimes both are found in man, and the latter is a common parasite in the paunch of the ox.

† French *fasciole*, *douve*. German *Bind-*, *Egel-*, or *Leberwurm*, *Egelschnecke*, *Doppelloch*.

body-cavity properly speaking) and peculiar shape. It was christened *Fasciola hepatica** by Linné, and is incorrectly called *Distoma hepaticum* by some authors. The liver-fluke is an Entozoon or internal parasite, and is a Trematode or perforated worm of the family *Distomidæ*. The position of this family will be seen from the following, in accordance with the classification of Dr. Cobbold.†

{ Class Helmintha.

{ { Sub-Class Sterelmintha.

{ { { Second Order Trematoda, with suckorial pores or openings, soft roundish or flat bodies, visceral organs lodged in the parenchyma of the body, mostly hermaphrodites, generally visible to the naked eye.

{ { { Families.

- | | | | | |
|----------------|------------|--------------|----------|------------|
| 1. Monostomidæ | } a. Di- | } Generation | | |
| 2. Distomidæ | | | genea† | alternate. |
| 3. Tristomidæ | } b. Mono- | } Develop- | | |
| 4. Polystomidæ | | | } genea† | ment |
| 5. Gyrodactylæ | | | | |

* Latin *fasciola*, a band.

† *Entozoa*, 1864.

‡ Van Beneden.

PART II.

THE ANATOMY OF THE LIVER-FLUKE.

THE anatomy has been well studied by English, French, and German physiologists, but nevertheless, owing to the very complex structure, there are many points that still want clearing up.

The external form is shown in figure 7. The length varies from three-quarters to one inch, and the width in the greatest part is half an inch. The head and neck, and the position of the two suckers, are shown in the figure. The oral sucker, placed at the anterior end of the fluke, is oval and perforate. It serves, together with the pharynx, as a passage for the

bile on which the animal feeds, as a prehensile organ and for aiding in locomotion, while the pharynx also aids in preventing the regurgitation of the swallowed food (Dr. Cobbold). The ventral sucker, or *acetabulum*, is placed immediately below the root of the neck. It is imperforate, being simply a cup-shaped disk of use in progression, and probably for attachment to the mucous membrane of the bile-ducts or "pipes." The general colour of the body is a pale brownish-yellow with a slight rose tint.

Examined through a pocket-lens, the body is seen to be covered with a number of spines which point towards the posterior end. By gently raising these with a forceps we see an outer transparent cuticle (*epidermis*), and an inner dense fibrous true skin. Beneath are numerous bands of muscles composed of longitudinal, transverse, and diagonal fibres (Dr. Cobbold).

All the tissues of the body are highly contractile.

DIGESTIVE SYSTEM.—This is closely connected with that of the Planarians of our ponds and ditches. A series of dark lines branching downwards and outwards on either side marks the position of the digestive organs. There is a very short *œsophagus*; the digestive system permeates every part of the body, and it may be said to constitute a double tree-like stomach, all of whose branches terminate in blind cæcal extremities. The contents are chiefly bile from the gall-ducts of the host.

AQUIFEROUS OR WATER-VASCULAR SYSTEM (see fig. 12).—This system, which can be seen with a pocket-lens, terminates at the tail end in a small opening (*foramen caudale*). Some of the vascular terminations anastomose (see fig. 14). In order to see this Dr. Cobbold recommends a half-inch objective. The minute tubes give

passage to a colourless fluid in which float numerous granules.* They are supposed to be akin to the capillary system of the higher animals. According to Leuckart a thick layer of cells with granular contents, and with a distinct nucleus—constituting the cutaneous glands—is freely traversed by the terminal twigs of the vascular system.

REPRODUCTIVE SYSTEM.—This is extremely complicated, and is shown in figure 9. The Liver-Fluke is an hermaphrodite.

The Female Organs.—Professor Simonds* describes them as follows:—*aa* = the *vitelligenes* or yelk-forming organs. The yelk-sacs are clustered around minute tubes in the form of branches whose stems are connected with two larger ducts *bb*. These receive the contents of smaller tubes which

* *The Rot in Sheep*, 1880. The first edition of this valuable pamphlet appeared in 1862. It is now out of print.

transmit by two horizontal branches *cc* to an ovoid body (or *germ-stock*) situated in the centre of the creature at about its upper third. From the germ-stock a short duct rises and leads to the *uterus*, *ee*. The limit of the uterine duct is marked as a small brown-coloured rosette-like figure immediately below the *acetabulum*. The oviduct passes from the *uterus* to the male organ.

The Male Organs.—*dd* are the *vasa deferentia* (see also fig. 11). The *testes* are a series of convoluted tubes *ff*, which in places seem to have cæcal beginnings (*gg*). A central light-coloured space seen extending two-thirds of the way down the body marks the regions of these organs. Some cluster round the germ-sac, and Professor Simonds believes that impregnation takes place here, although this is opposed to the view of most physiologists. At any rate colourless ova with thin

coverings are first seen in the short duct leading to the *uterus*. In the latter organ the eggs become yellowish-brown, and the shells thicker and harder.

Nervous System.—This has been studied by Mehlis, Blanchard and Leuckart. A pair of cephalic ganglia is situated in the space between the oral sucker and the pharynx. From that are given off two main branches or lateral nerves, which run downward parallel, and give off secondary branches to the sides of the body.

The liver-fluke was known from the earliest times, and was described by Gabrecinus in 1547.* Its anatomy was first made out by Govard Bidloo in a Latin tract† published in 1689. The figures given in

* For the literature of the subject, see Davaine, *Traité des Entozoaires*, and Professor Simonds' pamphlet.

† *Observatio de animalculis in ovino aliorumque animalium hepate detectis*.

Youatt's 'Sheep' are, the author finds, reduced from his, and are altogether wrong. Eyes are drawn and described, when the creature possesses none; a flat mouth is shown opening laterally, when the organ is an oval sucker; the part described as the bowels is really the convoluted *uterus*. It is curious to find the inaccurate figures of the seventeenth century inserted in such a standard work as Youatt.

PART III.

THE LIFE-HISTORY OF THE LIVER-FLUKE.

THE life-history of *Fasciola hepatica* has only very lately been made clear; several important links were missing, but thanks to the labours of Thomas* in England and of Leuckart† in Germany, the missing links have been found, and the chain of evidence is now complete. Cobbold, Ercolani,‡ and other naturalists, had studied the oval stage,

* See *Journal of the Royal Agricultural Society* for 1881-3, and *Quart. Journ. Microsc. Soc.* 1883, in which a full account of the life-history is given.

† See *Zool. Anzeiger*, and *Arch. f. Naturgesch.* for 1882.

‡ *Sull' ovulazione dei Distomi epatico e lanceolato delle pecore e dei buoi. Rendicont. Acad. Sc. Istit. Bologna*, 1880-1, pp. 123-30.

and Professor Leuckart* had described the ciliated embryo some years ago, but, previous to 1881, the stages of existence between the embryo and the adult were unknown, although those of allied species had long before been made out.

(1.) *The Egg and Embryo*.—In rotten sheep the eggs occur in large numbers in the bile-ducts and gall-bladder, giving the bile a dark colour and a sandy appearance. They pass with the bile into the intestines, and thence from the host with the droppings.

The oval egg, according to Professor Thomas, has a smooth transparent yellowish-brown chitinous shell, and is from $\cdot 105$ to $\cdot 145$ mm. long, and from $\cdot 066$ to $\cdot 09$ mm. broad. In one case he obtained 7,400,000 eggs from the gall-bladder of a sheep whose liver contained 200 flukes. At the time of

* *Die menschlichen Parasiten*, s. 864. A translation of this valuable work has lately appeared in our language. A second edition, *Die Parasiten des Menschen*, 1879, etc., is now in progress in Germany.

expulsion the eggs exhibit a finely segmented condition of the yolk* (see fig. 16). The primitive ovum in its descent through the oviduct is cleaved ; its development in the bile-ducts can go no further, as a lower temperature is necessary for this. Professor Thomas found that at the most favourable temperature—from 23° C. to 26° C.—the embryo is formed in from two to three weeks.

Figure 1 shows a very early stage in the development of the embryo. It was examined by Professor Thomas shortly after being taken from the liver. The embryo surrounded by the secondary yolk-spheres—physiologically equivalent to the white of a fowl's egg—is shown at *a*—the granular structure is depicted in one only of the latter. As time goes on the body of the embryo elongates, and gradually occupies the whole length of the egg. When ready

* Dr. Cobbold, *Parasites*, 1879.

to emerge, the embryo lies curved on itself at one side of the egg with the head end directed towards the lid. Between the head and the lid is a cushion of jelly-like substance. The bright border = *cilia*. The embryo moves about inside, and by so moving and extending itself the lid or *operculum* (*b*) flies open, and the embryo struggles out into the water—the cushion of jelly-like substance pouring out before it—and begins to swim. The *head-papilla* is retractile, and is drawn in when the animal swims, but it becomes an effective boring apparatus on the discovery of the host.

The body is covered with *cilia*, pointing backwards, by means of which the creature swims and gyrates vigorously in the manner of Infusoria. Covering the whole surface of the body is a layer of flat cells arranged usually in five rings, and bearing the *cilia*. Beneath is a granular tissue of muscle-fibre; at the anterior end are two

crescentic eye-spots, and about the middle of the body on each side is a long tongue-like *cilium* which is in constant motion. The eye-spots are surrounded by what appears to be the digestive tract; the rest of the body is filled with germinal cells. Leuckart says the caudal extremity sometimes displays evidences of a cleft. The embryo lives about 8 hours in water, but will exist longer in mucous—in a feebly alkaline solution of peptine, it was alive for three days. Professor Thomas supposes that it bores its way through the muscular foot of the little snail *Limnæus truncatulus* (fig. 17), but as it is generally found in the lung of that mollusk, and close to the kidney, it is not unlikely that the embryonic parasite is introduced by adhering to the mucous of the snail.

(2.) *The Sporocyst and Rediæ*.—Having found the host, the embryo undergoes the following changes: It loses the outer

layer of flat cells, and assumes an elliptical shape (fig. 3). The eye-spots become detached and changed in form; the embryo gradually increases in size; the germinal cells become larger--at first oval and then oblong—and break up into separate balls of cells or germs of the next generation; ten ciliated funnels appear about the middle of the body. *Figure 4* shows a *sporocyst* containing six germs of different sizes. By the eleventh day the most advanced germs (or *rediae*)* have cells so arranged as to form a nearly spherical pharynx leading into a short intestine. At the opposite end two short blunt processes or legs grow out of the sides—these prevent the animal from slipping in the body of the host. The *sporocyst* is now .6 mm. long; by the end of the thirteenth day when ready to issue it is .27 × .11 mm. long. The pharynx of the

* Willemoes-Suhm declares that the *redia* of *F. hepaticum* lives in *Planorbis marginata*, but he probably refers to that of *Distoma lanceolatum*.

inner-or daughter-nurses or *rediae* is distinct, and the digestive tract a simple sac. Some of the germs feed in the tissues of the host, others migrate into other organs as the liver.

By the twenty-third day the *rediae* are from .6 to .7 mm. long, and the germinal cells have begun to separate into spherical cells. The *rediae* escape by the wall of the sac opening—however they sometimes generate by division.

Figure 5 shows a *redia* half grown. Each one contains germs which become daughter-nurses similar to itself, or else which develop into—

(3.) *Cercariæ*.—Tadpole-like animals with a flat oval body, and a long slender tail.* The adult *redia* may grow to $\frac{1}{16}$ of an inch, and contain about twenty germs. The *cercariæ* escape from the parent by a special

* A fluke has been found beneath the human skin, indicating that the *cercariæ* possess great boring powers.

opening, and then crawl, and wriggle their way out of the snail. At the beginning of the seventh week undeveloped *cercariæ* are $\frac{1}{4}$ mm. long. The *cercaria* has two suckers corresponding to those of the adult fluke. It soon comes to rest, and attaches itself to blades of grass. It draws its body up into a ball, exudes a gummy substance which hardens, and forms a snowy-white envelope, and becomes—

(4.) A *Cyst* (or bladder), whereupon the tail is wriggled off. The *cyst* perishes in a few weeks unless it is swallowed by a sheep or other quadruped. On being taken up into a fresh and larger kind of host, in about seven weeks it will develope into the full-grown liver-fluke, and so have completed the strange cycle of changes.* The young fluke when introduced is only about $\frac{1}{80}$ of an inch in length; and, the hinder

* Changes that show retrograde metamorphism and degeneration.

part growing more rapidly than the fore part (fig. 7), the adult in time becomes from 1 to $1\frac{1}{2}$ inches long.

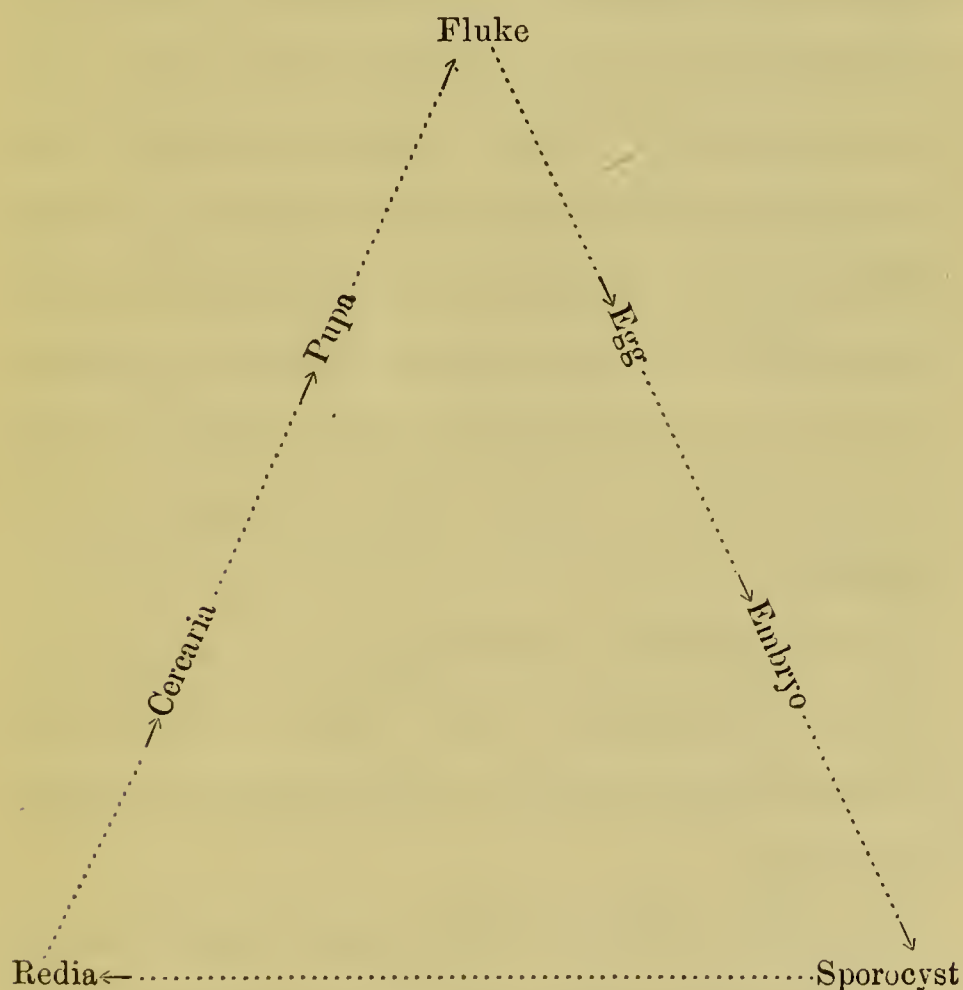
“If only the greatest degree of ordinary increase were reached, a single fluke might give rise to more than a hundred million descendants in the next generation of liver-fluke proper inhabiting the sheep.” *

These changes may be summarised thus:—

STAGE OF EXISTENCE.		CONDITION OF EXISTENCE.	
1. The <i>ovum</i> , or egg . . .	.	{	Passive in water or moisture.
2. The <i>embryo</i> . . .	Active		
3. The <i>sporocyst</i> , or germ-sac or nurse . . .	.	{	Inactive { Guest of the intermediate host, or <i>Limnæus truncatulus</i> .
4. The <i>redia</i> , or daughter-nurse . . .	.		
5. The <i>cercaria</i> , or tadpole-like larva . . .	.	{	Active, migratory { Partly in above, partly in water
6. The encysted <i>pupa</i> . . .	Passive		
7. The adult, or sexually-mature fluke . . .	.	{	Inactive { Guest of the ultimate host, the sheep.

* Professor Thomas, *Jour. Roy. Agr. Soc.* 1882.

Thus the embryo undergoes five changes before it becomes an adult fluke. This alternation of generation may be represented graphically thus:—



The pupal stage is like that of the *ovum* passive, while the cercarial is like the embryonic active. The parasitic stages are

alike in being inactive. It is only fair to mention that according to Pagenstecher the number of larval forms of the Trematodes may vary considerably under certain climatal conditions. Professor Thomas's conclusions with regard to the snail host *L. truncatulus*, have been confirmed by no less an authority than Leuckart, who published a paper giving a résumé of his researches a few months after our countryman's second paper had appeared in the 'Journal' of the Royal Agricultural Society.

The complete knowledge we now possess of the life-history of the fluke should have an important bearing on the disease known as the rot.

The first hint of the transformations of the liver-fluke appears to have been given by Benjamin Price, who asks pertinently, when discussing how the "insect" gets into sheep, "might not its form have

changed with its situation? ”* That rot was associated with the presence of flukes in the biliary ducts was shown by Ellis in 1749.

Probably before the end of that century this had been assigned as the cause of the rot. Dr. Harrison, writing in 1804, includes this view among others then prevalent, and R. Parkinson, in 1810, clearly looked upon the presence of flukes in the liver as the origin of the disease.

* *Bath Letters and Papers on Agriculture*, 1780.

PART IV.

THE EFFECT ON SHEEP, OR THE PROGRESS OF
THE ROT.

THE encysted pupa, having found its way into the sheep's body, assumes a more or less active life, and migrates in time to the liver, but seven weeks elapse before it arrives at full sexual maturity (Thomas); thus, if the pupa pass into the sheep's body during warm and wet days in June and July (as is usually the case), no eggs will be passed out with the droppings before August or September. The above times may be a month earlier or a month later, but they rarely exceed this. The adult may live in the sheep's body one year, and possibly much longer (Thomas).

The fluke gradually finds its way down the intestines, and then passes out with the droppings. Its movements in the sheep's body are sometimes extended to the *uterus*, and even to the lamb in the womb (J. C. Frommani and other observers).

A sheep infected with the fluke, or which has the liver-rot,* at first eats ravenously and fattens quickly. The entrance of recently developed flukes into the biliary ducts acts for a time as a local irritant only; and, as such, the liver is kept in a state of activity, so that in turn more fat is deposited on the tissues. Farmers are well aware of this, and purposely put sheep on "rotting" pastures in order to fatten them before selling to the butcher. Although the rot

* Known also as the *rot*, *sheep-rot*, or *fluke disease*; provincially as *caw*, *coa*, *coath*, *coathe* or *coade*, *iles* or *bane*; in Australia as the *sheep-pest* or *fluke*; called in France, *cachexie aqueuse* or *pourriture*; in Germany, *Egelseuche*, *Fäule*; in Italy, *moria*, and in Spain, *morriña*.

at this early stage does no harm to the sheep or to the flesh, the wisdom of the practice is very doubtful; it is evident that so long as it prevails the disease can never be stamped out, but will be on the contrary encouraged. This was pointed out so long ago as 1790. All may go well for a year or a cycle of years, but at length an unusually wet season comes, and the havoc among our flocks is terrible. In 1879–80 it is estimated that 6,000,000 sheep suffered from the rot—that is one tenth of the whole quantity of the United Kingdom.* During those years the average rainfall over the infected districts was fully

* Until of late years the annual losses amongst the flocks of Great Britain were estimated at a million; but in 1809, 1824, 1830 and 1833, this large mortality is believed to have been doubled. During the wet winter of 1852–3, and again in the autumn of 1860, and early months of 1861, the rot was extensively prevalent.—Chambers's *Encyclopædia*, art. *Rot*.

one-fourth more than the general average.

In a few weeks the sheep begins to lose condition—the body become flaccid and begins to shrink. This is the commencement of the second stage. The entozoa have laid the foundation for structural changes, and impaired function of the liver. The bile is gradually changed in quantity and quality, and the liver can no longer effectively maintain its office of a sugar-forming organ, or an elaborator of fibrin. Imperfect chylication is a necessary accompaniment, and the blood soon lacks purity, and quality and quantity likewise, for its development is restricted (Simonds). There are outward and visible signs of these internal changes. By pressure on the hips a peculiar crackling sound is perceptible and the sheep *winces*. In examining for the rot the shepherd, holding the animal supported on the hinder

quarters between his thighs, turns the lid of the eye back, and looks at the blood-vessels of the white and the haw (*caruncle*). If they are red and numerous the sheep is pronounced healthy; if few, pale and faint-coloured or yellowish, the sheep probably has the rot. Dr. Harrison* believed that by a frequent examination of the eyes it is possible to discover the rot before the sheep commences to shrink. During the earlier stages the fluke is present in the bile-ducts and gall-bladder.

As the disease progresses the skin changes in colour from vermilion to pale red and becomes dry, the wool is easily separable from the felt; then the skin is dappled with yellow or black spots, the eyes lose their lustre and become white and pearly; the animal eats irregularly, and

* *An Enquiry into the Rot in Sheep, and other Animals*, 1804.

grows more and more thirsty; there is irregularity in the action of the bowels, and diarrhœa may set in from time to time. The most marked features of the later stages are the pendulous belly, the "razor back," due to the flesh falling away from the vertebræ, the "hollow back," due to the drooping of the loins, and the tottering gait. As the disease advances the breath becomes short and quick, and is occasionally accompanied by a slight and nearly inaudible cough (Simonds). Various dropsical swellings occur—*e.g.*, the sheep becomes chockered or "poked," due to a swelling under the chin from the fluid in the cellular membrane (Dr. Harrison). "There is no surer proof of approaching death than these œdematous swellings, for they indicate a dropsical condition of the entire system. The prostration of the vital powers day by day increases. The pulse becomes quick, wavering and in-

distinct. The animal lies a good deal, refuses all food, is in a state of semi-stupor and dies from pure exhaustion, as the consequence of general anæmia." * The rate of progress and the duration of the disease depend on a variety of circumstances, as the state of the weather at the time, the quality and quantity of food eaten, the previous condition of the sheep, its age, and the remedial measures taken.

According to Professor Simonds the pathology is as follows :—When the entozoa are numerous there is soon venous congestion of the liver accompanied with a soft or pulpy condition, and an alteration of its natural colour. When the flukes are of medium size, and have travelled from the main biliary ducts (which they enter from the *duodenum*) into its numerous and smaller ramifications for ultimately de-

* Professor Simonds, *op. cit.*

positing their ova, their existence produces pressure, persistent irritability, and increased vascular action, which lead to the coats of the ducts becoming thickened, and their calibre increased—hypertrophy with dilation takes place. These changes give an altered form, and often an increased size to some parts of the gland. Nature strengthens the walls by membranous development, and even by the deposition of calcareous matter (phosphate of lime and magnesia) within the animal tissue to prevent the entozoa from gaining access to the parenchymatous structure of the liver. This gives the liver a hardened condition. The same structural changes lead to a partial blanching of the lobule, and a greatly impaired function of the bile-secreting cells, so that at length the entire organ becomes of a yellowish or clay-like hue, with which the enlarged main biliary ducts greatly contrast, standing

out in its surface as bluish-white lines or bands.*

It is worth noting that a rotten liver when boiled remains flaccid or breaks to pieces, and that watery or "fluky" mutton is pale-coloured, and the gravy almost colourless. It is a relief to know that the latter when eaten can do no positive harm to the human system, but it is innutritious,† and therefore can do little good.

Dr. Harrison believed the rot to be due to poisonous effluvia, and to be analogous to the enteric fevers that attack man. This erroneous view was upheld by so good an authority on sheep as Youatt.

Dr. Harrison brings forward several remarkable instances of quick contamina-

* For the post-mortem appearance of the body, see Prof. Thompson, *Rot, or Fluke and Louping-ill in Sheep*, 1882, Prof. Simonds' pamphlet, &c.

† Dr. Cobbold, *Internal Parasites of our Domestic Animals*, 1873.

tion, which, rather than strengthening his own theory, are most valuable evidence in support of the explanation given in these pages (see No. 9 following). Some latter-day farmers regard exposure to wet, combined with innutritious diet, as the cause of the disease—it were as logical to say that marshy places are the cause of splenic apoplexy, because they are favourable to the development of the *Anthrax bacillus*.

Knowing as we now do the life-history of the liver-fluke, we can readily explain the following facts, most of which have been authenticated by the agricultural experience of more than 100 years:—

FACT.

1. The rot is generally found in districts where the soil and subsoil are of a clayey, loamy and tenacious nature = "rotting" ground.

2. * The reverse is true—the rot is rare or absent in sandy, gravelly, chalky or calcareous districts = "sound ground."

3. The rot is prevalent after an unusually wet summer, and, if floods occur, land that may have been rotten is sometimes free of it, whereas land on which the disease has been unknown for years may become rotten. Sheep that have to wade for their food are not subject to rot.

4. Sheep are especially subject to rot. Hog-faced sheep are known to escape the infection. Lambs at Michaelmas are said to be more subject to the rot than full-grown ewes and wethers.

* In the neighbourhood of Hampton Poyle and Blechington, north of Oxford, the rot has followed the geological character of the ground very closely. All fields upon the Oxford clay have been dangerous, whether exposed to floods or not. On the other hand, floods on low porous grounds, or on gravel, appear to do no harm unless the water stands for a long time.—Thomas, *Journ. Roy. Agr. Soc.*, 1881.

EXPLANATION.

1. * In such districts the soil and subsoil are impervious to water, and consequently there is no *natural drainage*. (See also 3.)

2. * In such districts the rocks are porous, and there is natural drainage. (See also 3.)

3. A certain degree of warmth, and amount of water is necessary for the development of the larval fluke. Badly drained land in wet seasons may become a swamp, and fairly drained land may become very wet.* In much water the *cercariæ* cannot become encysted.

4. The sheep can graze closer than any other quadruped † except the kangaroo. The cysts become attached to grass stalks, and near the damp roots. Hog-faced sheep cannot crop close. At Michaelmas lambs are said to graze closer than ewes.

* See note on p. 44.

† Ruminants are also especially subject to the rot as the encysted *cercariæ* remain for an indefinite length of time in the first, second and third stomachs, whose secretion is non-digestive, and therefore in them they are not exposed to the solvent action of the gastric juice.—Simonds.

FACT.—*Continued.*

5. The rot is unknown in salt-marshes (noticed in 1614), and where sheep feed on sea-weeds.

6. Good pastures do not produce the rot.

7. Land well-dressed with caustic lime or salt will not produce the rot.

8. The infectious months are said to be May and June (Gabriel Plats) and July. Most practical men regard the autumnal months September and October as the dangerous ones.

9. Many instances are known of sheep having contracted the rot from grazing only for a very brief time on certain land (see Harrison, Simonds, &c.).

10. With one single night of frost the danger is over for the year.

EXPLANATION.—*Continued.*

5, Salt kills all the stages of the liver-fluke, and also the intermediate host.

6. Good pastures are well drained. (See 3.)

7. Lime and salt kill the *cercariæ*. (See 5.)

8. The snail host is buried in mud* in winter. A few eggs are hatched in April if warm—more in May; June and July are the chief months. Several months must elapse before the *cercariæ* are formed within the snail, and seven weeks before the fluke reaches sexual maturity, hence generally speaking the rot does not show itself until the autumn.

9. Such lands contain encysted pupæ which the sheep have swallowed with the herbage.

10. Great cold kills the different stages of the liver-fluke.

* Dr. Turton says *L. truncatulus*, or the Ditch Mud Shell, is found “in marshes and ditches on the mud.”—*Manual of the Land and Freshwater Shells of the British Islands*, 1857, p. 211.

During 1879-1880, Scotland enjoyed immunity from the rot, which depended on the summer rainfall of those years having been less excessive than that of England, and on her more limited area of flooded meadow and old pasture. Generally an excess of rainfall combined with an elevated temperature is dangerous.

The liver-fluke has been found in the sheep, goat, argali, ox (rare),* zebra, humped camel, horse, ass, antelope, gazelle, red, roe, and fallow deer, hog, hare, rabbit, squirrel, goose, pigeon, pheasant, poultry, great kangaroo, beaver, and man. It is found throughout Europe, and in Greenland, N. America. The rot is known in Europe, from Spain to Norway, and in Egypt, Australia, Tasmania, and N. and S.

* For its presence in the liver of calves, see *Report on Liver-Rot*, Journ. Roy. Agr. Soc. 1881, pp. 148-151.

America. Thus the liver-fluke has a very wide distribution. *L. truncatulus* is also widely spread, for it is found throughout Europe, and in N. Asia, Morocco, Algeria, Madeira, Guatemala, &c.

PART V.

THE CURE OF THE ROT.

WHEN sheep are known to be infected, provided the disease is in the first stage, they should be removed to a good and dry pasture. This of itself is often sufficient to effect a cure. They should have a dry, liberal, and nourishing diet given them. Good hay, beans, peas, and a moderate allowance of oil cake and turnips may be given, but the food should be frequently changed. Mashed oats and salt given two or three times a day is an excellent remedy. Some sheep were given a quarter of an ounce of salt well mixed with half a pint of oats every day they were fed on a permanent pasture; they were preserved

from the rot, while the sheep not so treated perished. The farmer by this means realised fifty shillings per head profit, whereas the cost of this extra treatment was only three shillings per head.* This speaks volumes for the salt remedy. The Bedouin Arabs allow infected sheep to feed upon the *salt-wort*, and Australians theirs on the *salt-bush*. It should be remembered that good nourishing food strengthens the sheep in its battle against the disease, while salt kills the liver-fluke; it is also essential to the health of the sheep, for it stimulates digestion, supplies the bile with the necessary amount of soda, and helps to preserve the proper specific gravity of the blood (Simonds). Salt as a remedy† was known certainly as early as the sixteenth century. A great many so-called cures, chiefly herbal,

* *Western Morning News*, Oct. 4, 1882.

† See Professor Thompson's pamphlet on Liver-rot.

are to be found in old books, but salt is *generally an ingredient of them all.*

The chief remedy recommended by Robert Boyle to the Royal Society in the seventeenth century was about Allhallow-tide to compel sheep to swallow a small handful of salt, and to keep them from drinking anything for an hour afterwards. Breeding ewes must not have much salt given them, and there will probably be no need to give any sheep salt after November the first in each year (Thomas).

Professor Simonds recommends the following medicated food, half a pint of which may be given to each animal daily in addition to an ordinary allowance of corn or cake and hay-chaff:—

Finely-ground oilcake (linseed)	} each 1 bushel.*
„ pea-meal . . .	

* One drachm of sulphate of iron, $\frac{1}{2}$ oz. of salt well mixed with bran, oats, and bruised cake, is recommended in the *Report on Liver-Rot.*

Finely-ground salt	.	.	.	.	} each 4 lbs.
„ aniseed	.	.	.	.	
„ sulphate of iron	.	1 lb.			

If thought advisable one bushel of crushed oats and one of crushed maize may be added to the above. The salt, aniseed, and sulphate of iron are to be mixed together first, and then well incorporated with the cake and pea-meal. It may be used for three or four weeks in succession, but should be discontinued occasionally, especially if the animals become affected with diarrhoea. Sulphate of iron is a cheap and useful tonic, and, moreover, it enters largely into the composition of the red corpuscles of the blood.

While the *cercariæ* are still in the stomach they may be killed by salt and water, by turpentine, or by small doses of carbolic acid. One ounce of turpentine may be used dissolved in three ounces of milk and repeated daily for four or five days, and

after two or three days remission, again persisted in—but that is not desirable for in-lamb ewes.*

When the animal is visibly thinning, showing that the disease has taken a firm hold, it will be best to kill and sell him. However in the case of valuable breeds, or of pedigree-sheep an effort should be made to save him. The animal should be well housed, and kept warm, have plenty of dry food mashed with salt, and as little water as possible. In order to expel the flukes from the bile-ducts Professor Simonds advises the following:—

Oil of turpentine	.	.	.	} of each 2 drachms.
Nitric æther	.	.	.	
Linseed oil	.	.	.	2 ounces.

To be administered once a day for three or four days successively, at intervals of about fourteen days. However, when once

* *Report on Liver-Rot.*

flukes are in the biliary ducts, it is questionable whether anything can be done in the way of medicine.

The cure may be a tedious and expensive process, but, provided the strength of the sheep is kept up properly, and no fresh encysted pupæ are allowed to be swallowed, also provided the flukes are not present in the liver in very large numbers, the ultimate cure is a mere question of time. Although myriads of eggs may be laid by the flukes, those eggs cannot become hatched inside the sheep, but gradually pass out of the body, while the adult flukes themselves, in probably from twelve to eighteen months, reach their natural term of existence, and pass away in a dead state. Two or three flukes will not cause the rot—for the disease to be severe it is essential that a great number be present in the liver. It must be remembered that when the affection is cured the sheep is not likely to

show any improvement during summer grazing for perhaps a season or two.

When the disease has gone so far that the animal shows the razor back and the pendulous belly a cure is out of the question, and salt and the like are said to be worse than useless. If a cure at this stage were possible, the game clearly would not be worth the candle—the best way under such circumstances will be to destroy the sheep, and sell the carcase for what it is worth.

PART VI.

THE MANAGEMENT OF PASTURES WITH A
VIEW TO AVOID THE ROT.

DRAINAGE is the most important preventive, and if the so-called epidemics of the rot among our sheep lead to the better draining of our land all over the United Kingdom, these visitations of Providence will not have been sent in vain. The rot was once very prevalent in Lincolnshire, but since drainage on a large scale has been carried out there, it is much less known. Again, land notorious for rotting sheep has been almost, if not entirely cured by under-draining.

As “a wet furrow, a springy spot, or the

neighbourhood of a stagnant pool affords suitable hatching ground,*" these should be drained dry where practicable. In stiff clays, Professor Wallace advises the keeping of the land up in high ridges to aid surface drainage.* Hedges and ditches should be kept in good order. Good grasses should be sown. Dressings of lime and salt are admirable, as such will destroy all the life-stages of the parasite and intermediate host. Professor Thompson recommends a dressing of from five to eight hundredweight of rough ground rock-salt per acre in March, April or May. This dressing should be applied especially after the subsidence of water from flooded land. Where a dressing of the pastures is impracticable, Professor Thomas recommends the strewing of layers of lime or salt along the margins of ditches and streams; even soot

* *Report on Liver-Rot.*

† *Farm Live Stock of Great Britain*, 1885, p. 52.

has been found efficacious in this way. Dr. Rowe, a large sheep farmer, suggests a series of measures for stamping out the disease, but the main point consists in burning the grass in which fluky sheep have been pastured, and afterwards restocking with sound animals. This is an expensive method, and as flukes are brought to a certain spot by the agency of winds, floods, rain and insects, by the feet of men and horses, by rabbits, hares and other animals, and by manure, it would not be efficacious in the long run. When the entozoon once has a fair start it spreads rapidly, and our calculations may be upset for years. The droppings of rotten sheep kept in a yard should never be put on moist lands, or, if necessary, a little coal-tar oil should first be added to the manure. Fluky livers should be destroyed, or be boiled before they are given to dogs (Thomas). These suggestions are practical

and valuable, but it is questionable whether the searching for, and destruction of the ova and cysts of the fluke, and the entrapping of the little snail, *L. truncatulus*, by means of cabbage-leaves, &c. is practicable on anything like a large scale.

Further, even were the entire destruction of the latter possible, it is questionable whether it would be the means of the fluke being annihilated, for Leuckart has discovered that *L. pereger* (fig. 10) may be a host for the embryo, and very possibly other species may also be hosts. The liver-fluke is found in the United States and in Australia, but it is said that *L. truncatulus* is present in neither of these countries. This is purely negative evidence, but it strengthens the opinion that other snails and possibly slugs may act as the intermediate hosts. It is not probable that the embryo-fluke would die out on account of the destruction of its host, with-

out an active search for an equally suitable species.

Undoubtedly hares and rabbits are active agents in bringing flukes to some spots.* The Ground Game Act aids the farmer by encouraging him to kill such game, and will in this way more than counterbalance the evil of the increased destruction of poultry by foxes that is said to exist since the Act came into operation. The author believes the stamping out of the disease to be impracticable. No doubt in average years we can do much to reduce it to normal limits, but so long as we have wet

* "It has long been my opinion that hares and rabbits carry the disease on to fresh ground—hares more especially, as they travel over a greater amount of ground than rabbits do. During the last winter a great number of dead hares were picked up having all the symptoms of rot. This is one way of accounting for virgin land becoming infected."—C. Moir, M.R.C.V.S., in *Report on Liver-Rot*. See also the preface to this Essay.

seasons our sheep in certain districts are likely to suffer from the rot. The great thing is to drain well, and to give up the practice of fattening sheep on fluky pastures.

By keeping sheep off wet land, by ditching and draining, by providing good hay for winter use, by salting the hay when ricked, and by having rock salt within reach, Lord Penrhyn, in 1881, had not experienced a single case of the rot for a period of fifteen years.*

* *Report on Liver-Rot.* For the importance of drainage consult this report. It contains much evidence on this point from farmers and landowners of the United Kingdom.



